a1 Amdd

nonencapsulated outer lead 12'. The inner leads 11' overlap heat sink 5', but are electrically isolated from heat sink 5' by a dielectric material, e.g., a layer of an adhesive tape 6a. Metal bond wires 3 electrically connect each inner lead 11' to a bond pad of semiconductor chip 2. An insulative, molded resin encapsulate 4 forms the package body and covers semiconductor chip 2, inner leads 11', conductive metal bond wires 3, and upper surface 5a' and side surfaces 5b' of heat sink 5'. Planar lower surface 5c' of heat sink 5' is exposed at the lower surface of the resin encapsulate 4 in order to obtain improved heat discharge characteristics.

Please replace the paragraph starting on page 1, line 35, with the following replacement paragraph.

a2

Fig. 2 illustrates a conventional procedure for fabricating a conventional heat sink 5'. In particular, a pair of facing U-shaped slots 51' are stamped through a metal sheet 50'. A pair of opposing support bars 52' remain after slots 51' are stamped. Subsequently, support bars 52' are cut in a second stamping step. Since the support bars 52' are relatively thick, some elongation of support bars 52' occurs during the cutting operation. As a result, V-shaped protrusions 8 are formed on two opposing sides of heat sink 5'. This two step stamping process is used because of the substantial thickness of metal sheet 50' and support bars 52'. If a single stamping step were used instead, heat sink 5' would be bent. Consequently, an additional step to flatten heat sink 5' would be required.

Please replace the paragraph starting on page 2, line 10, with the following replacement paragraph.

a3

After heat sink 5' is cut from metal sheet 50', heat sink 5' typically is subjected to several complicated coating and treatment steps. For example, the exposed lower surface 5c' of heat sink 5' (Fig. 1) typically is sand blasted to facilitate marking and then plated with nickel. The encapsulated surfaces of a copper heat sink 5' are subjected to a well-known black oxidation process (adapted to form a CuO thin film and/or a Cu_20 thin film) that facilitates the attachment of encapsulate 4 to heat sink 5'.

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Please replace the paragraph starting on page 2, line 16, with the following replacement paragraph.

a4

Conventional heat sink 5' of package 1' and the methods used to make heat sink 5' have several disadvantages. First, as described above, heat sink 5' is too thick to be stamped out in a single stamping step, but rather requires two stamping steps. Second, because lower surface 5c' of heat sink 5' is exposed at the lower surface of the package body, the complicated nickel coating and sand blasting steps described above are necessary. Third, protrusions 8 on heat sink 5' cause turbulence in the flow of resin during the molding process, and possibly can cause the formation of undesirable voids in encapsulate 4. Fourth, because heat sink 5' is heavy, and is much thicker than inner leads 11', inner leads 11' may become bent during handling of the leadframe after heat sink 5' is attached thereto. Such a bend in the leads may cause short circuiting and may adversely affect wire bonding. Fifth, because lower surface 5c' of heat sink 5' is exposed, a more complicated mold is required than would be used for an ordinary leadframe that does not have an exposed heat sink. Finally, excess encapsulate flashes onto lower surface 5c' of heat sink 5' during molding. Accordingly, a deflash step is necessary to remove the excess molding compound. This deflash process typically includes a chemical deflash step, followed by a mechanical deflash step using a water jet rinse.

Please replace the paragraph starting on page 3, line 8, with the following replacement paragraph.

a5

One embodiment of a semiconductor package within the present invention includes a semiconductor chip encapsulated within a 28 mm square molded package body. The semiconductor chip is mounted on a fully encapsulated, flat plate (i.e., the heat sink), which may be formed of copper or other materials. Metal leads, which are much thinner than the plate, extend from a first end overhanging the plate within the package body to a second end outside of the package body. The plate may be adhesively attached to the inner ends of the leads with an electrically insulative, thermally conductive adhesive tape, or staked to pseudo tie bars that extend from the corners of the package. The package may be used for high power applications that require excellent heat dissipation characteristics.

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Please replace the paragraph starting on page 4, line 20, with the following replacement paragraph.

a6

Package 1 of Fig. 3 includes a semiconductor chip 2 that is centrally mounted on a planar upper surface 5a of an encapsulated metal plate, denoted as heat sink 5. A thermally conductive adhesive 6, which may be a film or a paste, attaches chip 2 to upper surface 5a of heat sink 5. A plurality of metal leads 7 each extend from an encapsulated first end that is adjacent to chip 2 to a second end that is outside of the package body formed by encapsulate 4. In particular, each lead 7 comprises an encapsulated inner lead 11 and an exposed outer lead 12. Inner leads 11 extend over and are attached to an outer peripheral portion of upper surface 5a of heat sink 5 by means of an electrically insulative, thermally conductive adhesive layer 6a comprised of, for example, a double-sided adhesive tape. A plurality of metal bond wires 3 each electrically connect an inner lead 11 to a bond pad of semiconductor chip 2. A resin encapsulate 4 forms a package body. Encapsulate 4 completely covers chip 2, bond wires 3, heat sink 5, and inner leads 11.

Please replace the paragraph starting on page 5, line 2, with the following replacement paragraph.

a7

Heat sink 5 may be formed of a variety of materials, such as copper, anodized aluminum, or ceramic (e.g., aluminum nitride). In view of experiments discussed below, a copper heat sink 5 for a 28 mm square high power package may have a thickness between upper surface 5a and lower surface 5c of 0.3 mm to 0.7 mm (e.g., about 0.5 mm). By contrast, copper leads 7 and conventional encapsulated die paddles (which are not heat sinks) typically have a thickness of about 0.12 mm to 0.15 mm. Thus, in this embodiment, heat sink 5 is two to 5.8 times thicker than leads 7.

Please replace the paragraph starting on page 6, line 5, with the following replacement paragraph.

a8

Fig. 5A is a schematic view illustrating a procedure for fabricating a heat sink 5 according to one embodiment of the present invention. Fig. 5B provides a side view of heat sink 5. Fig. 5C is an enlarged view of portion D of Fig. 5B.

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Please replace the paragraph starting on page 6, line 8, with the following replacement paragraph.

a9

As shown in Figs. 5A to 5C, heat sink 5 is fabricated in a single stamping ~~step by~~ stamping a square loop slot 51 through a metal sheet 50 having a thickness of 0.3 to 0.7 mm, e.g., 0.5 mm. Heat sink 5 may be stamped in one step, as opposing to the two stamping steps required to form heat sink 5' of Fig. 1, because metal sheet 50 of Fig. 5A is significantly thinner than metal sheet 50' of Fig. 2 (0.3 to 0.7 mm verses 1.0 to 3.0 mm).

Please replace the paragraph starting on page 6, line 13, with the following replacement paragraph.

a10

When heat sink 5 is downwardly punched from metal sheet 50, downward-extending burrs 9 (Fig. 5C) may be formed at the edge of lower surface 5c of heat sink 5. To avoid tears in adhesive layer 6a of package 1 of Fig. 3, upper surface 5a of heat sink 5 opposite burrs 9 should be attached to adhesive layer 6a.

Please replace the paragraph starting on page 6, line 27, with the following replacement paragraph.

a11

Fig. 10A is an alternative semiconductor package 60 within the present invention. Package 60 is the same as semiconductor package 1 of Fig. 3 except with respect to the fastening of heat sink 5 to the leadframe of the package. In package 60, adhesive layer 6a is omitted, and a small layer of encapsulate 4 is between heat sink 5 and the portion of inner leads 11 that overhangs heat sink 5. In package 60, heat sink 5 is supported in the central region of the package by encapsulated members that are separate from the leads. In particular, as shown in Fig. 10B, heat sink 5 is mechanically fastened to members that formerly were part of the leadframe used to make package 60. In this example, the members are four, down set, electrically isolated pseudo tie bars 26 that each extend diagonally from a corner of the package body towards chip 2. (Pseudo tie bars 26 are described in further detail below with respect to leadframe 20 of Fig. 6A.) A stake-like metal protrusion 61 extends from corner portions of upper surface 5a of heat sink 5 through a hole in each pseudo tie bar 26. Each protrusion 61 is stamped or swaged against the respective pseudo tie bar 26 so as to form a metal to metal connection. In package 60, heat transmitted from chip 2 to heat sink 5 is believed to primarily dissipate by conduction through encapsulate 4 to inner leads 11.

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Please replace the paragraph starting on page 8, line 17, with the following replacement paragraph.

Figs. 7A and 7B show an alternative metal leadframe 10 within ~~the present invention.~~ Leadframe 10 includes features, discussed further below, that enable easier and superior molding of the package body, reduce lead bending, and facilitate wire bonding of the leads.

a12

Please replace the paragraph starting on page 8, line 23, with the following replacement paragraph.

A plurality of metal leads (e.g., copper) extend radially around central opening 14. Each lead has an inner lead 11 that will be encapsulated and an outer lead (denoted by the reference numeral 12 in Figs. 9A and 9B) that will extend outside of the package body. An outer end of inner lead 11 is integrally connected to the inner side of a dam bar 19 (see Figs. 8, 9A, 9B) of leadframe 10. An opposite free end of each inner lead 11 is adjacent to central opening 14 (Fig. 7A). An inner end of outer lead 12 is integrally connected to an outer side of dam bar 19 (Figs. 9A and 9B). An opposite outer end (not shown) of each outer lead 12 is connected to an outer frame (not shown) of leadframe 10.

a13

Please replace the paragraph starting on page 9, line 11, with the following replacement paragraph.

Fig. 8 is an enlarged plan view of portion "A" of Figs. 7A and 7B. Slot 18a is between at least one pair of inner leads 11 respectively arranged on opposite sides of a phantom line E that extends diagonally from one corner of the encapsulated region (denoted by dash lines 16) toward central opening 14 (see Figs. 7A and 7B). Slot 18a has a relatively wide portion outward of where adhesive layer 6a and heat sink 5 attach to inner leads 11, which allows resin to be introduced into the mold cavity through slot 18a without forming a turbulent or vortex flow. Slot 18a also has a relatively narrow portion inward of where adhesive layer 6a and heat sink 5 attach to inner leads 11. The wide portion of slot 18a has a width gl, and the narrower portion of slot 18a has a width g2. Preferably, the width gl is not more than 0.7 mm, and the width g2 is not more than 0.35 mm (while still being greater than the width of the space defined between adjacent inner leads 11).

a14

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